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ABSTRACT

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**A CAUSAL ANALYSIS OF RELATIONSHIPS
BETWEEN PERFORMANCE AND SATISFACTION
IN EIGHT AIRMAN SPECIALTIES**

By

Karl A. Hickerson, 1st Lt, USAF

USAF OCCUPATIONAL MEASUREMENT CENTER

Air Training Command

Lackland Air Force Base, Texas 78236

Joe T. Hazel

Joe H. Ward, Jr.

OCCUPATIONAL AND MANPOWER RESEARCH DIVISION

Lackland Air Force Base, Texas 78236

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SUMMARY

The purpose of this report is (1) to describe the directions taken by research on the relationships between performance and satisfaction since the 1950s; (2) to expand and test an analysis technique frequently employed in the study of performance and job satisfaction (i.e., cross-lagged panel correlation analysis); and (3) to provide a comprehensive bibliography of research concerned with performance and satisfaction.

A review of the literature revealed wide variability in the approaches taken to study performance and satisfaction relationships, although one predominant trend was the identification of measures and conditions under which a positive correlation between satisfaction and performance may be observed. Few of these studies were longitudinal, and few employed multiple measures of performance or satisfaction on more than a single occupational group. When positive correlations were observed between performance and satisfaction, they were universally small. The differences between findings from various studies suggested that performance and satisfaction were either independent, or that the relationship may be expected to differ considerably depending on the measures, jobs, and moderating conditions selected. The present study, therefore, sought to identify an approach to investigate performance-satisfaction relationships which could be useful in future Air Force job satisfaction research. The method developed and tested involved multiple variables and dynamic (i.e., Time 1/Time 2) analyses of several occupational groups.

A popular and more simple analysis technique for use with Time 1/Time 2 data, the "cross-lagged correlation" analysis, was compared with the multiple linear regression analysis techniques developed in this study. Simple regression analyses involved each combination of two pairs of performance and satisfaction variables (rated job and test performance; job interest and perceived utilization of talents and training), measured at both Time 1 and Time 2. Extended regression analyses involved these variables plus 20 moderating variables, including job complexity, difficulty, experience, aptitude, education, and several other personal history variables. In the extended analysis, non-linear and interaction relationships were also considered.

The cross-lagged correlation technique and simple regression analyses (assuming linear relationships between only two variables) yielded similar conclusions concerning causal influence. Extended regression analyses (assuming nonlinear relationships and multiple moderating variables) yielded different conclusions concerning causal influence. Analyses performed on all specialties combined (i.e., total sample) suggested test performance influenced job interest, job interest influenced rated job performance, and perceived utilization of talents and training influenced test performance. There were considerable differences in performance-satisfaction relationships between job specialties, however, particularly when the effects of job complexity, experience, and other moderating variables were controlled. Imposing regression weights generated from all eight specialties combined on the individual job specialty groups resulted in squared multiple correlation values which were highly variable, suggesting performance and satisfaction could not be reliably predicted on the basis of data used in combination with other occupational specialties.

The results of this research suggested that the relationship between performance and satisfaction is a complex one dependent upon the satisfaction, performance, and moderating variables selected, and the particular job specialty under consideration. The extended regression technique employed as a comparison to cross-lagged correlation analysis was considered to be more appropriate as a method for testing performance-satisfaction relationships because of its capability for controlling many of these important factors.

PREFACE

This research was completed under Project 7734, Development of Methods for Describing, Evaluating, and Structuring Air Force Occupations; Work Unit 77340501, Impact of Work-related Factors on Job Satisfaction and Career Decisions.

Performance effectiveness and productivity are of vital concern in the military services. One justification for the study of job satisfaction, beyond improving recruitment and retention, has involved the widely assumed positive relationship between satisfaction and job performance. Researchers often expect that their efforts to identify factors related to job satisfaction may have a payoff in terms of performance, beyond the dollar savings attributable to decreased turnover and retraining. There have been many directions taken by this kind of research, however. Thus, the first objective of this study was to review the literature with respect to important contributions in the area. A synopsis and list of the studies which were identified in this process, not including those cited in the text, is presented in an appendix.

One of the limitations on the application of information concerning performance and satisfaction relationships has been the question of causality. Since it is important whether performance or satisfaction may be enhanced through programs directed at the other, a second objective in this study was to evaluate a popular "causal-correlation" analysis technique which has provided the basis for generalizations about the direction of causal influence between performance and satisfaction. This report illustrates the use of an extended linear regression analysis technique based upon assumptions involved in the "cross-lagged correlation" approach. The extended causal analysis procedure was largely developed by Dr. Joe H. Ward, Jr., whose presentation of the linear models assumed in its use is included as an appendix of this report.

The study of performance and satisfaction is very active in civilian research, despite considerable performance data-gathering and analysis restrictions. If the development of a feasible method allows this interest to rise to a similar level in the military services, the authors hope this report will provide a point of departure for further research.

The authors wish to express their appreciation to Dr. Raymond E. Christal and Mr. R. Bruce Gould for their suggestions and to Sgt Michael Hutchinson for the computer analyses.

The views expressed in this report are those of the authors and do not necessarily reflect an endorsement of all aspects of the report by the United States Air Force or Department of Defense.

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A CAUSAL ANALYSIS OF RELATIONSHIPS BETWEEN PERFORMANCE AND SATISFACTION IN EIGHT AIRMAN SPECIALTIES

I. INTRODUCTION

Approaches to the Study of Performance and Satisfaction

Although the relationship between performance and job satisfaction has been studied over 40 years, the direction of causality of performance-satisfaction variables remains an unresolved question. Two possible reasons for this controversy are that manipulative research is difficult to accomplish in a working environment and the performance-satisfaction variables selected have differed widely between studies. While there have been numerous investigations recently on this complex problem, findings are inconsistent and results are only grossly comparable (Cohen and Turney, 1974; Federman, Lautman, & Siegel, 1973; Greene, 1973; Pritchard, 1973; Wanous, 1974; Wood, 1974).

Research of causal influences in the performance-satisfaction relationship has followed several directions. These include (1) identification of concomitant variables under which the relationship may be observed to change, (2) study of the effects of laboratory task performance on task liking, and (3) inferences of causal influence via panel correlation techniques (Greene, 1973; Lawler, 1968; Lawler and Suttle, 1973; Wanous, 1974). All of these approaches, however, involve certain difficulties or restrictions. For example, (1) concomitant variables have been studied only one or two at a time, (2) laboratory task performance-task liking results are not easily generalized to the work environment, and (3) panel correlation techniques have their own restrictive assumptions (Yee and Gage, 1968).

This report provides a modification and extension of one of the correlation techniques for estimating direction of causal influence, the "cross-lagged panel correlation" analysis. The extension is to multiple variables and occupational groups. In this study, the extended analysis was used to estimate causal influence between performance and satisfaction in eight Air Force occupational specialties separately and in combination. In addition, since the cross-lagged technique has frequently been used as a basis for generalizing simple causal conclusions involving performance and satisfaction, the extended analysis was used for evaluating whether cross-lagged correlation analysis could provide a realistic estimate of causal influence.

Cross-lagged Correlation Analysis

The term "panel" describes the arrangement of measurements in Time 1/Time 2 studies of two variables. Historically, the arrangement seems to have come from Tinbergen's *arrow scheme* for showing development and change in economic variables over time (Goldfarb, 1960). The term "panel" derives from "panel simulation" used by survey research analysts, in which a second survey of a group of individuals (the panel) is used to validate a model based upon responses from an initial survey (Lindzey, 1968). The *McGraw-Hill Dictionary of Modern Economics* defines *panel* as "A fixed sample of individuals . . . selected for the purpose of repeated interviewing . . ."

The cross-lagged panel correlation analysis technique was originally presented by Simon (1954, 1957), restated in two forms by Campbell (1963) and Pelz and Andrews (1964), and critically reviewed by several authors (Howard and Krause, 1970; Kenny, 1972; Sandell, 1971; Yee and Gage, 1968). It has recently been applied to performance and expectancy data (Lawler, 1968; Lawler and Suttle, 1973) as well as to performance and satisfaction data (Greene, 1973; Wanous, 1974). The "cross-lagged" correlations are those indicated by crossing lines connecting the two opposite corners of the panel (i.e., a time lag).

Figure 1 illustrates the measurements and correlations required of a simple cross-lagged correlation analysis, such as presented in Yee and Gage (1968). The technique assumes at the outset that (1) a change in the correlation of two variables over time indicates the existence of causal influence, (2) that the variable which is the most stable of the two across time is the causal agent, and (3) that no extraneous conditions are as important in their effects as are the effects of the two measured variables on each other. When the correlation between performance at Time 1 (P_1) and satisfaction at Time 2 (S_2) is greater than any other correlation, performance is generally said to have influenced satisfaction. Similarly, when the correlation between satisfaction at Time 1 (S_1) and performance at Time 2 (P_2) is greater than any other correlation, satisfaction is said to be the causal agent.

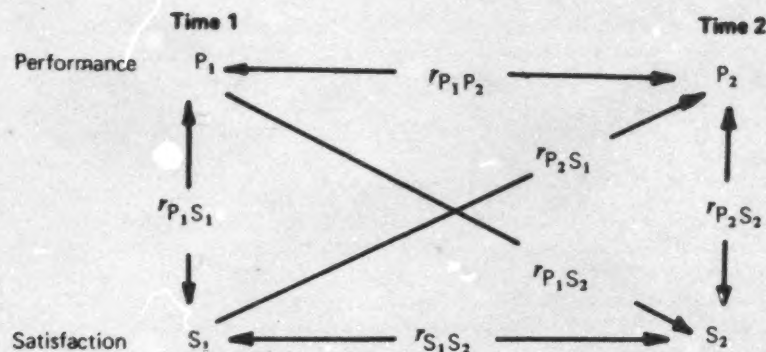


Figure 1. Correlations required of a cross-lagged correlation analysis of performance and satisfaction.

Despite the cross-lagged correlation analysis technique's value as an approach to the question of causal influence, it has some problems not fully discussed by its early critics. First, the cross-lagged analysis requires that all moderating variables are controlled by randomization. The relationship between performance and satisfaction appears to be too broad a problem to be properly investigated with a single set of panel correlations, particularly in light of current ignorance of differences between occupational groups. An investigator might make separate cross-lagged analyses to test the interaction of third variables, as did Greene (1973), but with each additional variable, the probability of conflicting results may be expected to increase.

A second major problem with the cross-lagged technique stems from the fact that it has been considered merely an approach to "estimating" causal influence; thus, investigators have assumed considerable freedom in claiming support for their research hypotheses. Yee and Gage (1968) and Sandell (1971) suggested that the direction of causal influence (toward an increase or decrease in the correlation between two variables across time) should be established prior to looking at the source of influence (the cross-lagged correlations). However, the current practice is to claim the existence of causal influence between performance and satisfaction without statistical comparisons of *both* the change in correlation across time and the cross-lagged correlations (Lawler, 1968; Wanous, 1974).

Third, the product-moment correlation coefficient represents the closeness of association of data under an assumed model which is very restrictive. The simplest and "best fit" model relating two variables may be a straight line, but the appropriateness of this model can and should be explored by comparing it with other forms of linear models (Ward and Jennings, 1973).¹ This seems particularly important in the case of cross-lagged correlation analysis, because conclusions are based upon the comparison of four correlation coefficients, involving the assumption of a simple linear relationship between four pairs of variables. Unless the two variables under consideration in a cross-lagged analysis are very carefully defined, it seems particularly misleading to estimate causal influence between them without considering interactions or nonlinearities. Expecting that performance influences satisfaction may be quite misleading, for example, if it is later observed that this is true only for certain jobs, experience levels, or restricted ranges of either variable.

A fourth difficulty with cross-lagged correlation analysis involves its restriction to only two measurements across time. In a review of longitudinal techniques for the study of attitude change, Broedling, Wiskoff, & Herbert (1975) considered certain quasi-experimental designs which included time-series and

¹ In this report, "Linear" models are of the form below, where the weighting coefficients can be multiplied by predictors defined in any way:

$$Y = w_0 + w_1 X_1 + w_2 X_2 + E$$

$$Y = w_0 + w_1 X_1 + w_2 X_2 + w_3 (X_1 * X_2) + w_4 X_1^2 + w_5 X_2^2 + E^1$$

panel techniques. Time-series techniques offer the power of trend analysis, not available with Time 1/Time 2 measurements. However, these authors point out the practical difficulties associated with subject attrition in complex longitudinal research. Data collection limitations in the present study precluded Time 3 measurements.

Statement of Problem

The cross-lagged correlation technique seems to have carried more weight for identifying causal influence than is warranted because it involves a model so highly restricted as to be of little value for operational application. The evidence which has come from cross-lagged correlation analysis of performance and satisfaction variables has not resulted in a clear indication of causal influence. The first of the Lawler studies (Lawler, 1968) suggested that performance was influenced by reward expectancy, but the second of his cross-lagged correlation analyses (Lawler and Suttle, 1973) provided little support of this hypothesis. In the Greene (1973) study, a series of cross-lagged analyses indicated that both merit pay and performance may have influenced later satisfaction, although the merit pay-performance relationship was unclear. The Wanous (1974) study did not clarify this situation. When performance was related to satisfaction, no relationships were observed, but when satisfaction was broken down into intrinsic and extrinsic components (satisfaction with the work itself versus satisfaction with pay and benefits), the cross-lagged correlations indicated Time 1 extrinsic satisfaction influenced Time 2 performance, but Time 1 performance influenced Time 2 intrinsic satisfaction.

The purpose of the present study was to determine the degree of consistency in the relationship between performance and job satisfaction among several Air Force job specialties, between different measures of satisfaction and performance, and between Air Force job incumbents with different background characteristics. It was hypothesized that the performance-satisfaction relationship would vary depending on each of these factors.

II. METHOD

Date Sources and Samples

Between 1967 and 1973, the occupational research program of the Air Force Human Resources Laboratory twice surveyed eight occupational specialties at approximately 3-year intervals. From approximately 16,000 airmen surveyed during this period, 1,352 airmen were identified who had completed occupational surveys in their specialty on two occasions. These 1,352 airmen represented a broad range of experience levels within the eight specialties. The job specialties, with number of cases and dates each was surveyed, are given in Table 1. The time periods between job surveys ranged from 30-45 months (39.5 average).

Data for job satisfaction variables were extracted from USAF Job Inventories, instruments used for the collection of demographic, job satisfaction, and task-level job information. Other self-reported data and performance measures employed in this study which were not available from these surveys were obtained from Air Force personnel records.

Performance Measures

The two performance measures were the Airman Performance Report (APR) and the specialty knowledge test (SKT). These measures are important factors in the Air Force Weighted Airman Promotion System.

The job performance rating (APR) was accomplished by the incumbent's immediate supervisor who was asked to consider the quantity, quality, and timeliness of the airman's work in his specified duties. The overall performance rating, one of several 9-point scales which appear on the rating form, was selected over other possible military rating scales because of its tie with "specified duties."

Valid scores on Airman Performance Reports were not available for all incumbents in four of the eight specialties such that matches could be accomplished within two years of the satisfaction variables.

Table 1. Air Force Job Specialties Sampled

	Air Force Specialty	N	Date of Time 1	Survey Time 2	Months Time1-Time 2
253XO	Weather Forecaster	146	Jun 68	Sep 71	39
301X1	Aircraft Electronic Navigation Equipment	185	Mar 68	Jun 71	39
301X4	Inertial and Radar Navigation Systems	170	Nov 67	Aug 71	45
325XO	Auto Flight Control Systems	190	Apr 68	Aug 71	40
421X3	Aerospace Ground Equipment	125	Mar 67	Oct 70	43
46XXX	Munitions and Weapons	158	Oct 67	Mar 71	41
571XO	Fire Protection	127	Apr 68	Oct 71	42
67XXX	Accounting and Finance	251			
		1,352			

Rather than include these poorly matched job performance scores, analyses in four specialties were restricted to the other performance measure (i.e., SKT). Subsequent tables reflect these missing data.

The SKT in any specialty is a written examination which reflects an airman's job knowledge of his specialty. The test in each specialty was checked at the time of administration for internal consistency with the Kuder-Richardson estimate of mean split-half reliabilities (Guilford, 1965). Although these data were no longer available at the time of this study, the average reliability of 476 tests administered in 1972 was .70 (Washington, Mitchell, & Davison, 1973).

Satisfaction Measures

The two measures of work satisfaction employed in this study were ratings of job interest and perceived utilization of talents and training. Job interest was rated on a 7-point scale from "very dull" to "extremely interesting." Utilization of talents and training was also rated on a 7-point scale, from utilized "not-at-all" to "perfectly." A report on the initial administration of these measures in 97 specialties indicated they were useful for identifying work-related factors relevant to overall job satisfaction (Gould, 1972).

Control and Moderating Variables

In addition, several self-reported and personal history variables were included in the study to evaluate certain possible multiple influences on the performance-satisfaction relationship. A listing of the performance-satisfaction (i.e., criterion, and the control and moderating variables) is presented in Table 2. Job difficulty was calculated with the regression equation provided by Mead (1970a; 1970b), based upon the number of tasks each incumbent checked and rated in his job inventory and the rated difficulty of those tasks as determined in a separate survey.

Time 1/Time 2 Measurement Matches

All performance and moderating variable measures taken from personnel records (Table 2) were selected to be in close proximity with job survey administration dates. The rated job performance-survey date matches were closer than the test performance-survey date matches, because test scores were registered at less frequent intervals. The distributions of time differences between performance and satisfaction measures were roughly normal. Test performance measures were matched within three months of the Time 1 satisfaction measures, and within eight months of the Time 2 satisfaction measures. Rated job performance measures were matched within one month of the Time 1 satisfaction measures, and within seven months of the Time 2 satisfaction measures. In no case were dates of rated or test performance the same at

Table 2. List and Source of First-Order Variables

Variable	Range	Type/Source	Time 1 and Time 2
Job Interest	1-7	Self-report/ Job Survey	Yes
Perceived Utilization of Talents and Tng	1-7	"	Yes
Specialty Knowledge Test, % Correct	0-100	Personnel Rcds	Yes
Airman Performance Report	1-9	"	Yes
Reenlistment Intent	1-5	Self-report/ Job Survey	Yes
Paygrade (rank)	1-9	"	Yes
Job Location, U.S. or Overseas	1,0	"	Yes
Months in Career Field	1-360	"	Yes
Total Months Military Service	1-360	"	Yes
Number of Subordinates	0-20	"	Yes
Skill Level	1-4	"	Yes
Years Education	10-18	"	Yes
Number of Tasks Performed in Job	1-360	Inventory/ Job Survey	Yes
Average Task Difficulty Per Unit Time	1-9	"	Yes
Job Difficulty Composite	-15-30	"	Yes
Career Airman	1,0	Self-report/ Job Survey	Yes
Number of Dependents	0-8	Personnel Rcds	Yes
Average Aptitude Index	0-100	"	No
Method of Assignment to Specialty			
Technical School	1,0	Self-report/ Job Survey	No
Direct to Duty w/o Test	1,0	"	No
Direct to Duty w/ Test	1,0	"	No
Converted w/o Training	1,0	"	No
Retrained	1,0	"	No
Reclassified	1,0	"	No
Reenlisted From Other Service Branch	1,0	"	No
Career Field Specialty	1-8	Personnel Rcds	No

Time 1 and Time 2. Analysis of variance did not reveal any systematic effects of closeness-of-match in the prediction of either performance or satisfaction.

III. ANALYSIS TECHNIQUES

Causal Analysis Using Linear Regression

In the following discussion, performance and satisfaction are designated P_1 , P_2 , S_1 , and S_2 , with subscripts indicating whether the measure was taken at Time 1 or Time 2. Regression analyses were performed separately for each of the four performance and satisfaction variables; hence, S_1 and S_2 indicate either job interest or perceived utilization of talents and training.

The primary disadvantages of the cross-lagged correlation analysis technique are that comparisons are restricted to two variables, and the relationship between the two variables is assumed to be linear. Both of these restrictions were avoided in the present study by extending the analysis to include the assumptions of non-linear relationships between performance, satisfaction, and moderating variables. This was accomplished by comparing linear regression models in the manner suggested by Ward and Jennings (1973). A

general discussion of the linear models assumed in this approach to causal analysis is presented in Appendix A.

In regression analysis, it is possible to test the effects of any one predictor relative to all other predictors included in the model. The linear regression technique was therefore first restricted to its simplest form, using only a first-order model involving those terms included in a cross-lagged analysis, and then extended to include the assumption of higher-order relationships and moderating variables. Linear regression analysis consolidated the comparison of several correlations required in the cross-lagged analysis, and it provided for independent assessments of the influence of performance and satisfaction on the other under a variety of assumed models.

The assumptions required by general linear regression analysis are contrasted with those of the cross-lagged analysis in Table 3. In the regression analysis, the Time 2 measurement of an hypothesized

Table 3. Assumptions Required in the Assessment of Causal Influence With Cross-lagged Correlation Versus Linear Regression

Cross-lagged Correlation	Multiple Linear Regression
1. Change in the correlation of two variables across time indicates causal influence.	1. Change in the hypothesized target variable (criterion) across time indicates causal influence.
2. The causal effects of the two variables on each other are more important than the effects of unobserved extraneous variables.	2. All of the potentially important causal agents are included in the starting model.
3. The Time 1 variable whose correlation with the opposite Time 2 variable is largest is the causal agent.	3. With their Time 1 values held constant, Time 2 variables which are significantly related to the criterion are causal agents.
4. The relationship between the two variables is essentially linear.	4. Any functional form expressing non-linearity and interactions can be assumed.

effect variable (the variable temporarily assumed to have been influenced) was designated as the criterion. All Time 2 performance and satisfaction measures were separately assumed to be effect variables. If no changes occurred between Time 1 and Time 2 measurements of the hypothesized effect variable, no predictors beyond the effect variable's Time 1 measure would produce a model with a significantly better "fit," and the Time 2 measure of the hypothesized effect variable would be said to be predicted best using only its Time 1 measurement. In such cases the product-moment correlation between Time 1 and Time 2 would approach 1.00, and it would be concluded that no causal influence had occurred. To the extent that P_2 and P_1 (and S_2 and S_1) were uncorrelated, however, it was possible to identify additional predictors that enhanced the prediction of P_2 (and S_2). In such cases it was concluded that some causal influence had occurred.

When the existence of causal influence was assumed ($P_2 - P_1 \neq 0$; $S_2 - S_1 \neq 0$), a variable was said to be a causal agent if its Time 2 measurement provided a significantly better prediction of the criterion (the hypothesized effect variable) than that provided by the hypothesized causal agent's Time 1 measurement alone. Causal influence was therefore assumed to be detectable as criterion variance which was significantly related to the unique variance in a second measure of an hypothesized causal agent. This assumption is analogous to the third cross-lagged assumption: if no influence occurred from an hypothesized causal agent S to an hypothesized effect variable P , the prediction of P_2 (beyond that

provided by the predictor P_1) would be no better with S_2 and S_1 than with just S_1 . In the cross-lagged analysis, this would be a case where correlations involving S_1 and S_2 were not different. If influence had occurred by S on P , however, the prediction of P_2 (beyond that provided by P_1 , S_1 , and other agents) would be enhanced by including S_2 in the model. In the cross-lagged analysis, this would be a case where the correlations involving S_1 and S_2 were different. A full explanation of this procedure as applied to actual data is given for a specific example in Section IV.

Full models were generated for both performance and satisfaction as hypothesized effect variables, as indicated in Table 4. Imposing the restrictions, implied by the hypothesis of no causal influence by

Table 4. Models Compared in Three Methods for Assessing Causal Influence

Cross lagged Panel Correlation Analysis		
$P_2 = a_0 + a_1 P_1 + E$	$P_2 = a_0 + a_1 S_2 + E$	$S_2 = a_0 + a_1 P_1 + E$
$P_2 = a_0 + a_1 S_1 + E$	$S_2 = a_0 + a_1 S_1 + E$	$S_2 = a_0 + a_1 P_2 + E$
Simple Linear Regression		
P_2 (full): $P_2 = a_0 + a_1 P_1 + a_2 S_1 + a_3 S_2 + E$		
P_2 (res): $P_2 = b_0 + b_1 P_1 + b_2 S_1 + E'$		
S_2 (full): $S_2 = a_0 + a_1 S_1 + a_2 P_1 + a_3 P_2 + E$		
S_2 (res): $S_2 = b_0 + b_1 S_1 + b_2 P_1 + E'$		
Extended Linear Regression		
P_2 (full): $P_2 = a_0 + a_1 P_1 + a_2 P_1^2 + a_3 S_1 + a_4 S_1^2 + a_5 S_2 + a_6 S_2^2 + a_7 M_{11} + a_8 M_{21} + a_9 (M_{11} * S_2)$ $+ a_{10} (M_{21} * S_2) + E$		
P_2 (res): $P_2 = b_0 + b_1 P_1 + b_2 P_1^2 + b_3 S_1 + b_4 S_1^2 + b_5 M_{11} + b_6 M_{21} + E'$		
S_2 (full): $S_2 = a_0 + a_1 S_1 + a_2 S_1^2 + a_3 P_1 + a_4 P_1^2 + a_5 P_2 + a_6 P_2^2 + a_7 M_{11} + a_8 M_{21} + a_9 (M_{11} * P_2)$ $+ a_{10} (M_{21} * P_2) + E$		
S_2 (res): $S_2 = b_0 + b_1 S_1 + b_2 S_1^2 + b_3 P_1 + b_4 P_1^2 + b_5 M_{11} + b_6 M_{21} + E'$		
Where		
P_1 — performance at Time 1		
P_2 — performance at Time 2		
S_1 — satisfaction at Time 1		
S_2 — satisfaction at Time 2		
$M_{k,ij}$ — some set of moderating variables		

performance and satisfaction on the other, yielded the restricted models identified in this table. Concomitant variables were included in full and restricted models in order to control for extraneous conditions which might have affected conclusions concerning causal influence. In addition, vectors which allowed for nonlinearities and interactions were included in some analyses to determine the consistency of conclusions under various assumed relationships.

Steps in the Analysis

Analyses were performed in four stages: (1) identification of changes in performance and satisfaction between Time 1 and Time 2; (2) comparison of the conclusions of cross-lagged causal analysis, simple linear regression analysis (involving only P_1 , P_2 , S_1 , and S_2), and extended linear regression analysis (involving nonlinearities, interactions, and moderating variables); (3) cross-validation of most parsimonious and efficient overall models predicting Time 2 performance and satisfaction against individual job specialties; and (4) identification of unique performance-satisfaction and moderating variable relationships within each job specialty. A summary of the steps involved in the simple and extended linear regression causal analysis procedures is given in Table 5.

Table 5. Steps Required to Test for Causal Influence in the Simple and Extended Linear Regression Techniques

Step 1:	Generate starting models for Time 2 performance and satisfaction criteria.
Step 2:	Generate restricted models deleting the Time 2 term(s) involving the hypothesized causal agent.
Step 3:	Statistically compare starting and restricted models.
If	
	(1) neither restricted model accepted, conclusion ambiguous.
	(2) both restricted models accepted, no causal influence.
	(3) the restricted model predicting Time 2 performance is <i>rejected</i> , and the restricted model predicting Time 2 satisfaction is <i>accepted</i> , satisfaction influenced performance.
	(4) the restricted model predicting Time 2 satisfaction is <i>rejected</i> , and the restricted model predicting Time 2 performance is <i>accepted</i> , performance influenced satisfaction.

IV. RESULTS AND DISCUSSION

Changes Between Time 1 and Time 2

As a preliminary step in the assessment of causal influence between performance and satisfaction, changes in these variables between measurements were evaluated. Analysis of variance indicated that job interest and perceived utilization of talents and training decreased in all eight specialties over the 3-year period between surveys ($p < .05$). Rated job performance (APR) increased in the four specialties where Time 1 data were available ($p < .05$). Differences between test performance (SKT) means were not interpretable because of possible changes in test difficulty. Correlations between the Time 1 and Time 2 measures of each of the key variables were: job interest, .40; perceived utilization, .40; rated job performance, .27; and test performance, .40.

Comparison of Causal Analysis Techniques

In the following discussion, the results of three causal analysis procedures are compared: (1) cross-lagged correlation analysis, (2) simple linear regression analysis involving an assumed linear relationship between a performance or satisfaction criterion and only three performance-satisfaction predictors, and (3) extended regression analysis involving the evaluation of nonlinearities and interactions between performance, satisfaction, and several moderating variables.

Cross-lagged analysis. Cross-lagged comparisons for all job specialties combined are given in Figure 2. Each set of data, containing six correlations, corresponds to one pair of performance and satisfaction measures at Time 1 and Time 2. Correlations were statistically compared with r to z transformations. The correlations between test performance (SKT) and both satisfaction measures (job interest, perceived utilization of talents and training, left side of Figure 2) changed significantly between measurement times ($p < .01$), but in neither case were the Time 2 correlations between test performance and the satisfaction measures significantly different from zero. In the two rated job performance (APR) models, on the other hand (right side of Figure 2), Time 2 performance-satisfaction correlations were significantly different from zero ($p < .05$) but were not different from Time 1 performance-satisfaction correlations. Cross-lagged comparisons did not yield a clearly identifiable source of causal influence.

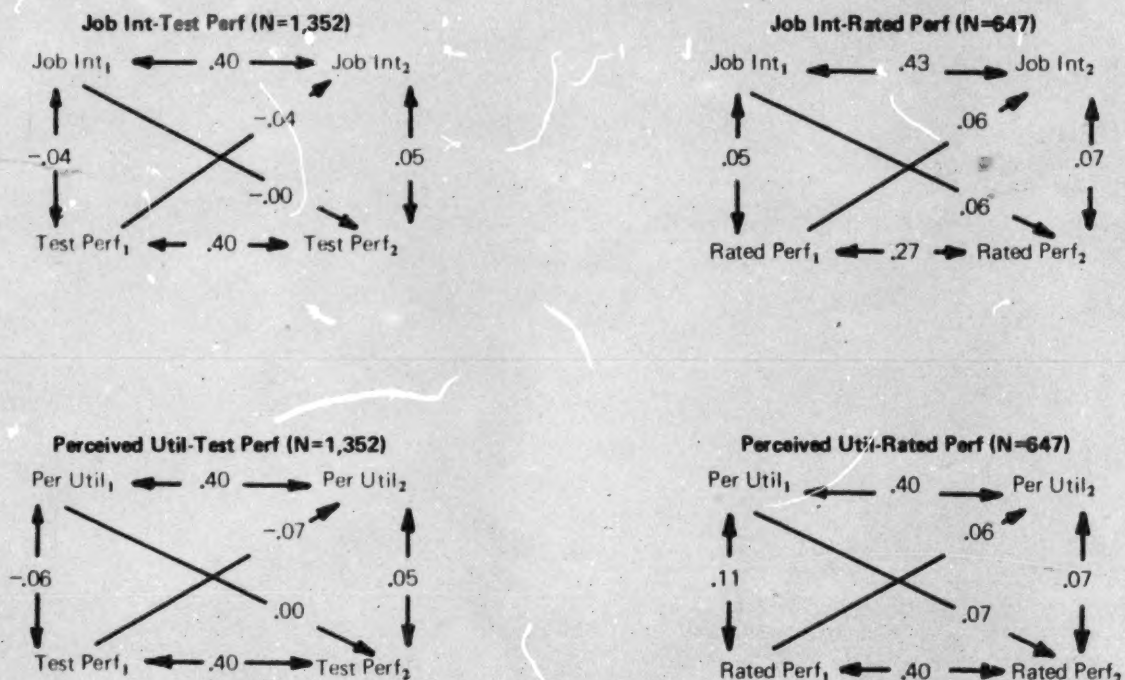


Figure 2. Cross-lagged correlation models for all combinations of performance and satisfaction variables.

A specialty-by-specialty examination of the correlations between all combinations of performance and satisfaction variables yielded different conclusions in different ladders. The four most important values for each combination are presented by specialty in Table 6 ($r_{p_1s_1}$, $r_{p_2s_2}$, $r_{p_1s_2}$, $r_{s_1p_2}$). These may be transcribed from Table 6 into the typical cross-lagged panel arrangement. Correlations $r_{p_1p_2}$ and $r_{s_1s_2}$ were not included in Table 6 to reduce exposition.

In the Weather Forecaster specialty, the correlation between job interest and specialty knowledge test performance increased from .05 to .08 between Time 1 and Time 2, and the cross-lagged correlation involving Time 1 test performance was larger than either of these values ($r_{p_1s_2} = .11$). These comparisons suggested that test performance may have influenced interest, although differences were small and non-significant. An increase in the correlations of job interest and perceived utilization of talents and training with supervisor rating were also observed, and in both cases the Time 1 attitude variables were more highly related to the Time 2 performance ratings than the earlier performance rating was to later attitude ($r_{s_1p_2} < r_{p_1s_2}$). Differences were again non-significant, however.

Table 6. Correlations Between Performance and Satisfaction Variables by Specialty

		Test Performance (SKT)		Rated Job Performance (APR)	
		Time 1	Time 2	Time 1	Time 2
Weather Forecaster (N = 146)					
Job Interest	(Time 1)	.05	.00	.07	.09
	(Time 2)	.11	.08	.04	.14
Perceived Util	(Time 1)	.05	-.05	.07	.10
	(Time 2)	.07	.02	.02	.14
Acft Elec Nav Equip (N = 185)					
Job Interest	(Time 1)	-.11	-.09	.01	.03
	(Time 2)	.09	.00	.07	-.02
Perceived Util	(Time 1)	.01	.07	.13	.11
	(Time 2)	.00	.12	.07	.08
Inertial and Radar Nav Sys (N = 170)					
Job Interest	(Time 1)	-.05	.02	-	-
	(Time 2)	-.08	-.14	-	-
Perceived Util	(Time 1)	-.14	-.05	-	-
	(Time 2)	-.13	-.15	-	-
Auto Flt Cont Sys (N = 190)					
Job Interest	(Time 1)	.04	.01	.04	.01
	(Time 2)	.03	.03	.03	.03
Perceived Util	(Time 1)	-.12	-.11	.07	.01
	(Time 2)	-.05	.07	.06	-.01
Aerospace Gnd Equip (N = 125)					
Job Interest	(Time 1)	-.16	-.09	-	-
	(Time 2)	.06	.12	-	-
Perceived Util	(Time 1)	-.09	-.03	-	-
	(Time 2)	.09	.08	-	-
Munitions and Weapons (N = 158)					
Job Interest	(Time 1)	-.05	.05	-	-
	(Time 2)	-.07	.20	-	-
Perceived Util	(Time 1)	-.16	.01	-	-
	(Time 2)	-.11	.20	-	-
Fire Protection (N = 127)					
Job Interest	(Time 1)	-.03	.15	.11	.08
	(Time 2)	.02	.01	.18	.23
Perceived Util	(Time 1)	.03	.08	.16	.13
	(Time 2)	.00	.01	.09	.14

Table 6. Correlations Between Performance and Satisfaction Variables by Specialty (Cont'd)

		Test Performance (SKT)		Rated Job Performance (APR)	
		Time 1	Time 2	Time 1	Time 2
Accounting and Finance (N = 251)					
Job Interest	(Time 1)	.07	-.01	—	—
	(Time 2)	.01	-.02	—	—
Perceived Util	(Time 1)	-.02	-.05	—	—
	(Time 2)	-.05	-.09	—	—

In the Aircraft Electronic Navigation Equipment specialty, the correlation between perceived utilization and test performance increased over the period. The relationship between cross-lagged correlations indicated the causal agent was more likely perceived utilization than test performance. The differences again only approached significance.

The cross-lagged comparisons in the Aerospace Ground Equipment specialty indicated both job attitude variables were likely influenced by test performance. The correlation between interest and test performance increased significantly over the interval ($p < .01$), and the correlation change between perceived utilization and test performance approached significance ($p < .10$); however, neither Time 2 correlation was significantly different from zero ($\chi^2 = .12, .08; p > .10$).

In the Munitions and Weapons specialty, the correlations between job interest and test performance increased over the period ($p < .01$) as did the correlations between perceived utilization and test performance ($p < .01$). The Time 2 correlations between these pairs of variables were significantly different from zero ($\chi^2 = .20, .20; p < .05$). The cross-lagged correlations indicated that the direction of influence was most likely attitude (job interest or perceived utilization) on test performance, although these correlations were small.

Finally, in the Fire Protection specialty, the correlation between test performance at Time 2 and job interest at Time 1 was larger than any of the other correlations involving these variables ($\chi^2 = .15; p < .20$), suggesting that interest may have influenced test performance. Rated job performance, however, was observed in exactly the opposite relationship with job interest: Only the correlation between Time 2 job interest and Time 2 rated job performance was significant ($\chi^2 = .23, p < .05$). No differences between any pairs of correlations in this specialty were significant.

Simple linear regression analysis. The results of the simple and extended regression causal analyses are presented for all specialties, combined, in Table 7. In the simple analysis, starting (full) models included only four variables (P_1, P_2, S_1 , and S_2), involving a Time 2 criterion and three predictors. Hypothesized causal agents are identified by the single deleted predictor in the column labeled "Restricted Model." Multiple correlations are presented for both starting (or full) models and restricted models; these values were nearly the same in all simple linear regression comparisons for any criterion. No Time 2 hypothesized causal agent was significantly related to the criterion as long as its Time 1 measure was included in the model. Comparisons between simple linear models for all specialties combined, therefore, yielded conclusions which were no different than those derived from the cross-lagged correlation analyses. That is, predicted performance was the same for incumbents with different Time 2 satisfaction (holding constant Time 1 satisfaction). Similarly, the predicted satisfaction was the same for incumbents with different Time 2 performance (holding constant Time 1 performance).

Extended linear regression analysis. Causal analysis tests with models assuming nonlinearities and interactions are also presented in Table 7. The starting models for these comparisons are identified as "extended" rather than "simple linear." Starting models included variables P_1, P_2, S_1, S_2 , moderators, and squares and cross products involving each of the performance and satisfaction variables. In the extended analysis, predictors deleted in restricted models included all terms involving the variable identified in

Table 7. Models Compared in Simple and Extended Linear Regression Causal Analysis, All Specialties Combined

Criterion (Time 2)	Starting Model	(N)	R	Time 2 Variable(s) Deleted in Restricted Model	R	F
Job Interest	Simple Linear	(1,352)	.701	SKT	.701	.509
	Simple Linear	(647)	.701	APR	.701	.522
	Extended	(1,352)	.746	SKT	.743	2.795*
	Extended	(647)	.744	APR	.736	1.132
Perceived Util	Simple Linear	(1,352)	.696	SKT	.696	.807
	Simple Linear	(647)	.696	APR	.696	.186
	Extended	(1,352)	.748	SKT	.746	1.012
	Extended	(647)	.731	APR	.728	1.192
Test Performance (SKT)	Simple Linear	(1,352)	.550	Job Int	.550	.514
	Simple Linear	(1,352)	.550	Util	.550	.812
	Extended	(1,352)	.660	Job Int	.655	.907
	Extended	(1,352)	.660	Util	.656	3.282*
Rated Job Performance (APR)	Simple Linear	(647)	.179	Job Int	.179	.317
	Simple Linear	(647)	.179	Util	.179	.186
	Extended	(647)	.521	Job Int	.521	2.320*
	Extended	(647)	.554	Util	.547	1.761

* $p < .05$.

Table 7. For example, in the extended analysis test of causal influence by test performance on job interest, the restricted model included all predictors involved in the starting model except Time 2 SKT, squared Time 2 SKT, and all Time 2 SKT-moderator variable cross-products.

With nonlinearities and interactions considered, three comparisons indicated possible sources of influence across all specialties combined: Time 2 test performance enhanced the prediction of job interest, Time 2 perceived utilization enhanced the prediction of test performance, and Time 2 job interest enhanced the prediction of rated job performance (all $p < .05$). A statistically significant portion of the variance in Time 2 job interest, test performance, and rated job performance was therefore attributed to complex relationships between an hypothesized causal effect variable and the interactions or complex relationships involving an hypothesized causal agent.

Because earlier analyses suggested important differences between specialties, further extended-regression causal analysis tests were performed within each job specialty rather than for a combined sample. These tests are presented by specialty in Table 8. As in the full sample analyses, F comparisons between full and restricted models tested the predictive contribution of the set of variables indicated under "Restricted Model."

In the Weather Forecaster specialty, where the cross-lagged correlations suggested that both satisfaction measures may have influenced later rated performance, but test performance influenced job interest, one clear relationship was noted: a second measure of perceived utilization significantly enhanced the prediction of rated performance ($p < .05$). In the Munitions and Weapons specialty, where job interest was suggested to have influenced test performance on the basis of cross-lagged comparisons, several directions of influence were suggested. The second measure of job interest enhanced the prediction of test performance ($p < .01$), but the second measure of test performance also enhanced the prediction of job interest ($p < .05$). In addition, a second measure of test performance enhanced the prediction of perceived utilization ($p < .01$), and a second measure of perceived utilization also enhanced the prediction of test performance ($p < .05$). No other tests were significant for any occupational group, although tests of both test performance and rated job performance on job interest approached significance in the Fire Protection

Table 8. Extended Regression Analysis Tests for Causal Influence,
Individual Specialties

Job Specialty	Criterion (Time 2)	R	Time 2 Variable Set Deleted in Restricted Model	R	F
Weather Forecaster (253XO)	Job Interest	.469	APR	.459	.773
		.469	SKT	.459	.778
	Perceived Util	.437	APR	.415	1.537
		.437	SKT	.435	.101
	Test Perf (SKT)	.696	Job Int	.694	.461
		.704	Util	.701	.566
	Rated Job Perf (APR)	.358	Job Int	.348	.533
		.428	Util	.377	3.456*
Aircraft Electronic Nav Equip (301X1)	Job Interest	.462	APR	.440	2.081
		.462	SKT	.454	.772
	Perceived Util	.362	APR	.359	.170
		.362	SKT	.332	2.080
	Test Perf (SKT)	.519	Job Int	.513	.649
		.518	Util	.508	1.203
	Rated Job Perf (APR)	.386	Job Int	.381	.444
		.379	Util	.379	.047
Inertial and Radar Nav Systems (301X4)	Job Interest	.386	SKT	.363	1.670
	Perceived Util	.374	SKT	.339	2.271
	Test Perf (SKT)	.354	Job Int	.345	.555
		.371	Util	.327	2.909
Auto Flight Cont Systems (325XO)	Job Interest	.485	APR	.484	.090
		.485	SKT	.480	.584
	Perceived Util	.475	APR	.475	.018
		.475	SKT	.455	2.220
	Test Perf (SKT)	.624	Job Int	.620	.900
		.628	Util	.619	.996
	Rated Job Perf (APR)	.436	Job Int	.431	.483
		.434	Util	.432	.064
Aerospace Ground Equip (421X3)	Job Interest	.535	SKT	.523	.951
	Perceived Util	.473	SKT	.473	.005
	Test Perf (SKT)	.666	Job Int	.660	.549
		.663	Util	.663	.483
Munitions and Weapons (46XXX)	Job Interest	.421	SKT	.354	4.660*
	Perceived Util	.513	SKT	.464	4.880**
	Test Perf (SKT)	.487	Job Int	.363	10.490**
		.420	Util	.362	4.173*
Fire Protection (571XO)	Job Interest	.479	APR	.451	1.980
		.479	SKT	.438	2.777
	Perceived Util	.469	APR	.460	.621
		.469	SKT	.451	1.305
	Test Perf (SKT)	.534	Job Int	.522	1.106
		.501	Util	.491	.782
	Rated Job Perf (APR)	.390	Job Int	.341	2.490
		.370	Util	.348	1.032

(Table continues on next page)

Table 8. Extended Regression Analysis Tests for Causal Influence, Individual Specialties (Cont'd)

Job Specialty	Criterion (Time 2)	N	Time 2 Variable Set Deleted in Restricted Model	R	F
Accounting and Finance (67XXX)	Job Interest	.428	SKT	.428	.061
	Perceived Util	.414	SKT	.409	.579
	Test Perf (SKT)	.485	Job Int	.477	.871
		.484	Util	.475	1.320

*p < .05.

**p < .01.

specialty ($p < .10$). In the Aircraft Electronic Navigation Equipment specialty, tests of rated job and test performance on job interest and utilization, respectively, also approached significance ($p < .10$).

Conclusions varied widely between the cross-lagged, simple regression analyses, and the extended linear regression causal analyses for the individual job specialties. In the Weather Forecaster specialty, all three techniques suggested perceived utilization influenced rated job performance over the period, and in the Munitions and Weapons career field, all three suggested job interest influenced test performance; however, extended regression analysis also suggested test performance may have influenced job interest among Munition and Weapons specialists. No other sources of causal influence suggested by cross-lagged analysis were fully supported by the comparison of extended models, holding constant concomitant variables. Results from all three analyses indicated considerable variability between measures as well as between specialties. For example, although job interest and perceived utilization of talents and training were themselves highly correlated, performance variables were negatively related to job interest and positively related to perceived utilization in some specialties. A summary of performance-satisfaction relationships identified in the extended regression analyses, presented in Table 9, illustrates this variability.

Table 9. Summary of Results of Extended Linear Regression Causal Analysis for Performance and Satisfaction

Air Force Specialty Code	N	Direction of Influence
Overall Sample (8 Specialties)	1,352	Interest → APR Utilization → SKT SKT → Interest Utilization → APR
253XO Weather Forecaster	146	Interest ↔ SKT Utilization ↔ SKT
46XXX Munitions and Weapons	158	

Cross-Validation of Models Derived From All Specialties Combined

Earlier results indicated considerable differences in performance and satisfaction relationships between specialties. As a systematic approach for measuring the overall degree of these differences between specialties, a cross-validation procedure was employed at this point in the analysis. The technique indicated whether predictor variables developed for one sample had the same relationship to the criterion for another sample (Guilford, 1965, p. 516). Performance and satisfaction regression weights were derived by least-squares procedures for most parsimonious predictors over all specialties combined, following procedures suggested by Ward and Jennings (1973). Imposing these weights on individual job specialty subsamples produced multiple correlations which were highly variable. These "forced" multiple correlations ranged

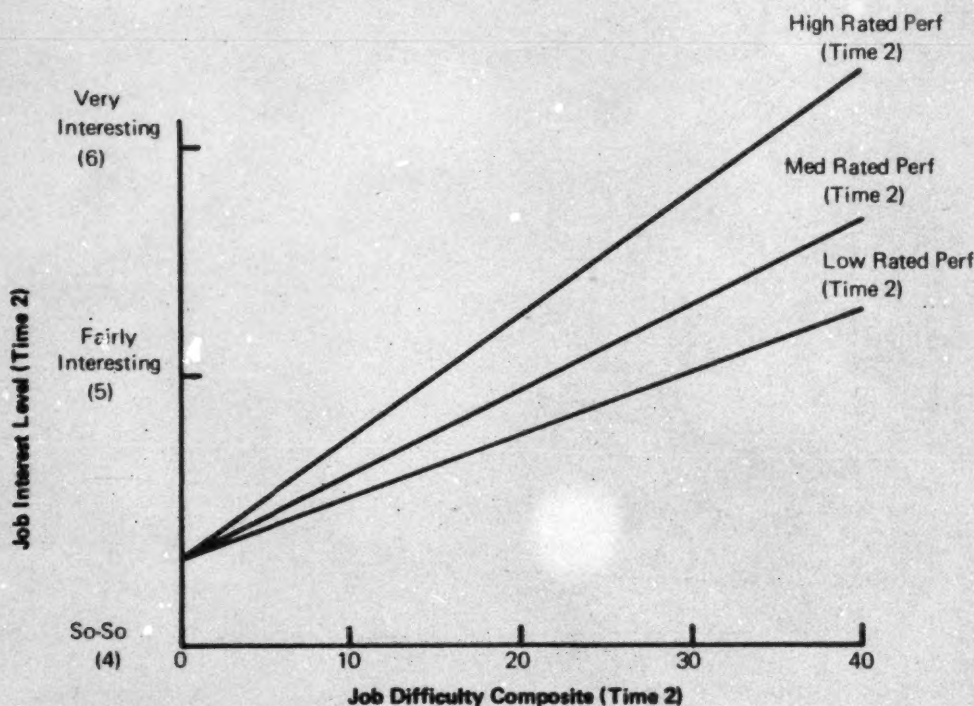
from .37 to .54 across specialties in the prediction of job interest, .37 to .48 for perceived utilization, .26 to .39 for APR, and .37 to .70 for SKT. This variability was consistent with earlier observations of differences in performance-satisfaction relationships between specialties.

Prediction of Satisfaction and Performance with Moderator Variables

Results in the previous causal analyses illustrated various performance-satisfaction relationships, holding concomitant variables constant. The purpose of the procedure described in this section was to identify the unique interactions involving performance or satisfaction and concomitant variables in the prediction of Time 2 satisfaction or performance, respectively.

The most parsimonious and efficient predictive models were derived individually for each specialty following the procedures described in Ward and Jennings (1973). Although some of the variables related to performance and satisfaction criteria were found to be the same across several of the individual specialties, many differences were also noted. Related specialties (e.g., Aircraft Electronic Navigation Equipment and Inertial and Radar Navigation Systems) did not have the same predictor-criterion relationships when parsimonious models were derived. Time 2 job difficulty and rated performance interacted in their effect on job interest for Inertial and Radar Navigation incumbents ($p < .05$), for example, but not for the Electronic Navigation incumbents where Time 2 rated performance, by itself, was significantly related to job interest ($p < .05$).

The interaction of Time 2 job difficulty and Time 2 rated performance was significantly related to job interest in six of the eight specialties ($p < .05$). This relationship in all specialties was of the form illustrated in Figure 3. The criterion in Figure 3 is job interest at Time 2; each curve represents the relationship of Time 2 job difficulty and job interest for one level of Time 2 rated performance (high,



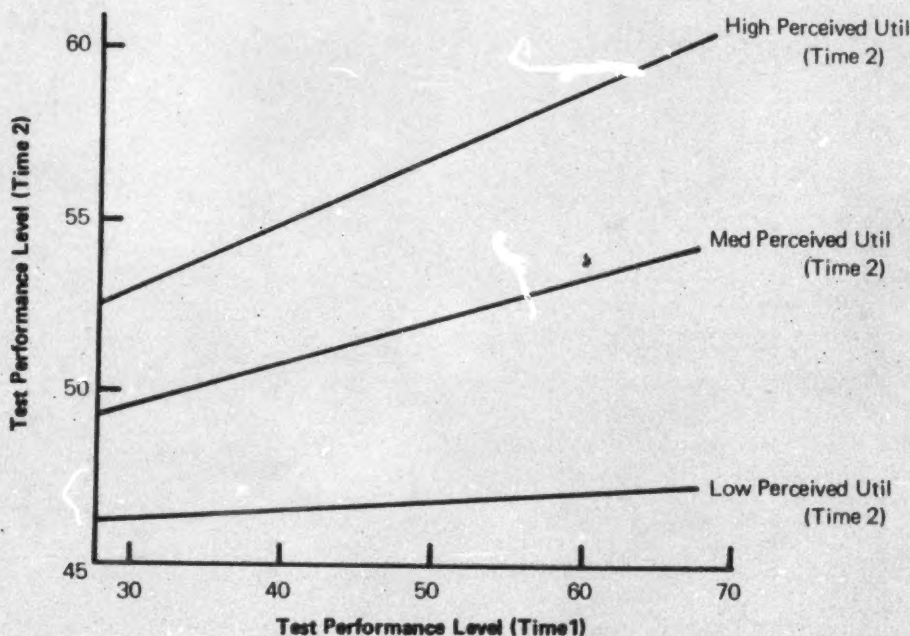
$$JI_2 = a_0 + a_1 JI_1 + a_2 (JDC_2 * APR_2) + E$$

Figure 3. Job interest as a function of Time 2 rated job performance and Time 2 job difficulty.

medium, or low). The rate of increase in job interest with increasing job difficulty is shown to be greatest for incumbents with high rated performance. The relationship illustrated in Figure 3 was similar for all specialties. The difference in predicted job interest scores between high and medium rated performance (a rating of 9 vs 8) at *high* job difficulty ranged from .45 in Accounting and Finance to .80 in Aerospace Ground Equipment. A predicted difference of 1.00 on the job interest scale would be roughly equivalent to the difference between reported job interest of "fairly" versus "very" interesting.

Time 2 job difficulty and rated performance were also found to interact in the prediction of perceived utilization but only in four specialties. These were: Aerospace Ground Equipment, Accounting and Finance, Fire Protection, and Auto Flight Control Systems. The relationship was similar to that in Figure 3. In the remaining four ladders, no performance variables were found to be important in a context of five other predictors. Time 2 job attitude variables were not necessarily important for predicting performance in the same specialties where performance was found to be important for predicting attitude. When aptitude and job experience variables were present in the predictive models, job interest or utilization variables were found to add significantly to the prediction of test performance in only two specialties. In Fire Protection, Time 2 test performance was higher for incumbents with higher levels of Time 1 test performance, but more so for incumbents with high perceived utilization at the approximate time of the second performance measure. A similar result was obtained for Time 2 job interest and Time 1 test performance in the Munitions and Weapons specialty, as the correlation between the two test performance measures was much higher for incumbents with high job interest at Time 2. These results are graphically displayed in Figures 4 and 5.

Between-ladder differences were also apparent in the prediction of Time 2 rated performance. Among the four specialties where Time 1 rated performance data were available, two final models did not include



$$SKT_2 = a_0 + a_1 APR_1 + a_2 (SKT_1 * Util_2) + E$$

Figure 4. Test performance at Time 2 as a function of perceived utilization at Time 2.

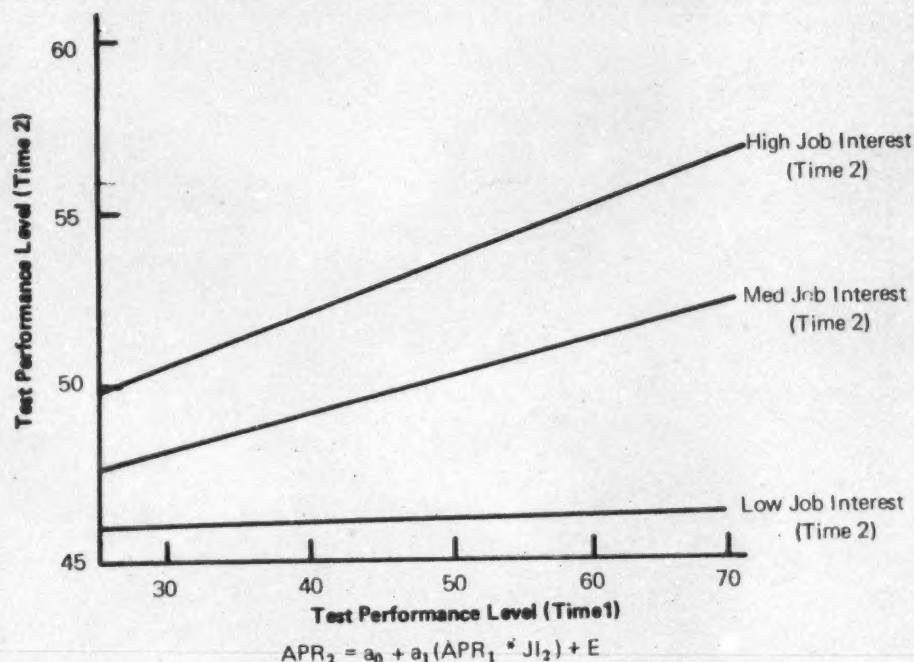


Figure 5. Test performance at Time 2 as a function of job interest at Time 2.

job attitude variables (Aircraft Electronic Navigation Equipment and Auto Flight Control Systems), and two did. In the Fire Protection specialty, job interest at Time 2 was significantly related to the performance ($r = .14$), but in addition, perceived utilization at Time 1 moderated the relationship between rated and test performance at Time 2, as this relationship was positive only for incumbents with medium or high perceived utilization at Time 1. Of the four ladders without Time 1 APR, three had final models in which perceived utilization at Time 1 was a weak predictor. These were Inertial and Radar Navigation, Munitions and Weapons, and Aerospace Ground Equipment. The low multiple correlation coefficients, for APR models without Time 1 measures, suggested these results are of little practical significance; however, the consistency with which Time 1 perceived utilization was related to Time 2 rated performance across ladders suggested some influence by job attitude variables on subsequent performance. This hypothesis could only be partially tested with the causal analysis techniques discussed previously because of the unavailability of Time 1 APR data in four of the specialties.

Other causal agents. As a final check against alternative explanations of the causal influence conclusions reported previously, some additional extended linear regression causal analyses were performed involving performance and satisfaction with job complexity, job difficulty, and job experience variables. Results were consistent with earlier findings: in the two specialties where performance and satisfaction were found to be related (Weather Forecaster and Munitions and Weapons), none of these concomitant variables was suggested to be causally related to both performance and satisfaction. Thus, there were no alternative causal explanations for the performance-satisfaction causal relationships in these two specialties. A summary of performance-satisfaction and other variable causal relationships is given in Table 10.

Table 10. Summary of Results of Extended Linear Regression Causal Analysis for Performance, Satisfaction, and Other Variables

Air Force Specialty	N	Direction of Influence
Overall Sample (8 Specialties)	1,352	Experience → APR Complexity → APR
253XO Weather Forecaster	146	(Only performance-satisfaction relationships)
301X1 Electronic Navigation Equip	185	Complexity ↔ SKT, APR Difficulty ↔ Util
301X4 Inertial and Radar Navigation	170	Complexity ↔ Int, Util
325XO Auto Flight Control Systems	190	Complexity ↔ Int, Util
421X3 Aerospace Ground Equip	125	Difficulty ↔ Int Difficulty ↔ SKT
46XXX Munitions and Weapons	158	Complexity ↔ SKT
571XO Fire Protection	127	(No relationships)
67XXX Accounting and Finance	251	No. Tasks ↔ Int, Util

V. CONCLUSIONS

The question, "performance and job satisfaction, which causes which?" cannot be answered in the present study without reference to a particular job specialty, measure of performance, measure of satisfaction, and model selected for the analysis of relationships (including or not including additional variables). First the wide variability in multiple correlations and variables identified as important in restricted models in this study suggests that findings from one job specialty cannot be generalized to other specialties. While Munitions and Weapons Specialists, with higher job interest in 1967, tended to have greater increases in test performance in 1971, for example, increasing job interest would not have had a positive influence on test performance among Inertial and Radar Navigation Systems personnel, whose job interest and test performance were negatively correlated over the same period.

Second, the results of this study clearly support the view that the relationship between job performance and satisfaction varies as a function of the selected measures. Even consistently correlated job interest and perceived utilization of talents and training were found to be related to different predictor variables.

Third, the cross-lagged correlation analysis technique should be viewed as a highly restricted model suitable for examining the relationship between only two variables. As the models vary to include other related variables and the assumption of higher-order relationships, the conclusions concerning causal influence will also change. Research in this area has seldom involved more than a single measurement of key variables; therefore, the tendency has been to generalize on this basis only. The findings of this study illustrate, however, that entirely different conclusions for the relationship between satisfaction and performance may result from models including multiple measurements of the independent and dependent variables.

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APPENDIX A. LINEAR REGRESSION MODELS IN STUDIES OF CAUSATION

I. INTRODUCTION

Yee and Gage (1968) discuss several methods for estimating source and direction of causal influence. Each of these methods concentrates on the interpretation of product-moment correlation coefficients to infer causal influence. Correlation coefficients represent very simple relations and do not allow for expression of nonlinearities and interactions among sets of variables. A model that is so restrictive may not adequately represent real situations.

In studies involving Time 1/Time 2 measures on variables such as job performance and job satisfaction or teacher attitudes and student attitudes, it seems reasonable to consider the possibility that interactions and/or nonlinear relations might be needed.

The following discussion indicates an approach for developing linear models to allow for interactions and nonlinear relations that might exist in causal influence studies. The basis of these developments is provided by Bottenberg and Ward (1963) and Ward and Jennings (1973).

II. EFFECTS OF JOB SATISFACTION ON JOB PERFORMANCE

Effect of Time-2 Satisfaction on Time-2 Performance

A specific example will be used to describe the linear model's approach to a study of job performance and satisfaction. First, we examine the question of whether differences in Time-2 Satisfaction result in differences in Time-2 Performance—while controlling for other variables that might be involved.

Define the following vectors:

$P^{(1)}$ = performance measure for a person at Time 1

$P^{(2)}$ = performance measure for a person at Time 2

$S^{(1)}$ = satisfaction measure for a person at Time 1

$S^{(2)}$ = satisfaction measure for a person at Time 2

$M^{(i)}$ = other vectors representing ($i = 1, \dots, k$) attributes measured at Time 1 or Time 2

The values of any Time-2 measure should not be influenced by satisfaction or performance during the Time-1/Time-2 period

U = the unit vector

The dependent variable of interest is represented by $P^{(2)}$ and we express:

$P^{(2)}$ = function of vectors involving $M^{(i)}$, $P^{(1)}$, $S^{(1)}$ and $S^{(2)}$

A specific example might appear as follows:

Let

A = one of the $M^{(i)}$ vectors representing an aptitude measure at Time 1.

T = one of the $M^{(i)}$ vectors representing years of total active federal military service at Time 1.

Then consider an assumed model:

$$\begin{aligned} P^{(2)} = & b_0 U + b_1 A + b_2 T + b_3 (A * T) + b_4 P^{(1)} + b_5 [P^{(1)} * A] + b_6 [P^{(1)} * T] + b_7 S^{(1)} \\ & + b_8 [S^{(1)} * S^{(1)}] + b_9 [S^{(1)} * A] + b_{10} [S^{(1)} * T] + b_{11} [S^{(1)} * P^{(1)}] + b_{12} S^{(2)} \\ & + b_{13} [S^{(2)} * S^{(2)}] + b_{14} [S^{(2)} * A] + b_{15} [S^{(2)} * T] + b_{16} [S^{(2)} * P^{(1)}] \\ & + b_{17} [S^{(2)} * S^{(1)}] + E^{(1)} \end{aligned}$$

where

$(A * T)$ = a vector of direct products of the elements of A and T

$[S^{(1)} * S^{(1)}]$ = a vector of direct products of elements of $S^{(1)}$ with itself; i.e., the squares of the elements of $S^{(1)}$

$(V * W)$ = a vector of direct products of elements of any vectors V and W .

While it would be possible to explore the appropriateness of this model, we will assume it as a starting model for investigating the question of the effect of Time-2 Satisfaction on Time-2 Performance. One way to infer that satisfaction measured at Time 2 has no causative effect on performance at Time 2 is to consider individuals who have exactly the same measured values on aptitude, years of federal military service, Time-1 Performance, and Time-1 Satisfaction, but who have different measured values of Time-2 Satisfaction. Then we can hypothesize that there is no difference between expected Time-2 Performance of these individuals.

An explicit and abbreviated form of the hypothesis is

Hypothesis 1:

$$\xi[P^{(2)}] (a_i, t_j, p_{1k}, s_{1q}, s_{2r}) = \xi[P^{(2)}] (a_i, t_j, p_{1k}, s_{1q}, s_{2r'})$$

for all $i, j, k, q, r, r' \quad r \neq r'$

This says that the expected Time-2 Performance for a person with aptitude a_i , total service t_j , Time-1 Performance p_{1k} , Time-1 Satisfaction s_{1q} , and Time-2 Satisfaction s_{2r} , is equal to the expected Time-2 Performance for a person with aptitude a_i , total service t_j , Time-1 Performance p_{1k} , Time-1 Satisfaction s_{1q} , but Time-2 Satisfaction $s_{2r'}$.

Imposing these restrictions implied by the hypothesis on the assumed model results in a restricted model that has no vectors involving $S^{(2)}$

$$P^{(2)} = c_0 U + c_1 A + c_2 T + c_3 (A * T) + c_4 P^{(1)} + c_5 [P^{(1)} * A] + c_6 [P^{(1)} * T] \\ + c_7 S^{(1)} + c_8 [S^{(1)} * S^{(1)}] + c_9 [S^{(1)} * A] + c_{10} [S^{(1)} * T] + c_{11} [S^{(1)} * P^{(1)}] + E^{(2)}$$

The F -statistic for this test is

$$F_1 = \frac{(R_1^2 - R_2^2)/(18 - 12)}{(1 - R_1^2)/(N - 18)}$$

If we accept this hypothesis one might infer that Time-2 Satisfaction has no causative effect since persons who are the "same" at Time 1, but who have different satisfaction levels during the period from Time 1 to Time 2, have the same Time-2 Performance.

However, if we reject Hypothesis 1, it might be of interest to determine if there is any interaction between satisfaction at Time 2 and any of the other attributes. We will determine if the difference in effect of Time-2 Satisfaction is constant across all patterns of values of the other attributes.

In terms of the expected values we can write

Hypothesis 2:

$$\xi[P^{(2)}] (a_i, t_j, p_{1k}, s_{1q}, s_{2r}) - \xi[P^{(2)}] (a_i, t_j, p_{1k}, s_{1q}, s_{2r'}) = k_{rr'}$$

for all $i, j, k, q, r, r' \quad r \neq r'$

where $k_{rr'}$ is an unknown difference associated with levels r and r' .

Imposing these restrictions on model 1 above gives the restricted model

$$P^{(2)} = d_0U + d_1A + d_2T + d_3(A * T) + d_4P^{(1)} + d_5[P^{(1)} * A] + d_6[P^{(1)} * T] \\ + d_7S^{(1)} + d_8[S^{(1)} * S^{(1)}] + d_9[S^{(1)} * A] + d_{10}[S^{(1)} * T] + d_{11}[S^{(1)} * P^{(1)}] \\ + d_{12}S^{(2)} + d_{13}[S^{(2)} * S^{(2)}] + E^{(3)}$$

The F -statistic is

$$F_2 = \frac{(R_1^2 - R_3^2)/(18 - 14)}{(1 - R_1^2)/(N - 18)}$$

Effect of Time-1 and Time-2 Satisfaction on Time-2 Performance

While the previous approach might be appropriate to determine the effect on performance of satisfaction changes during the period from Time 1 to Time 2, it might be of interest to consider another approach.

We now examine the question of whether differences in satisfaction at Time 1 (measured at beginning of the second time period) or differences in satisfaction at Time 2 (measured at the end of the second time period) result in differences in Time-2 Performance—this will include controlling for other variables. This examines effects due to *all* satisfaction information.

Consider individuals who have exactly the *same* measured values on aptitude, years of federal military service, Time-1 Performance, but who have *different* measured values of *both* Time-1 and Time-2 Satisfaction. Then we can hypothesize that there is no difference between expected Time-2 Performance of these individuals.

The model independent form of this hypothesis is

Hypothesis 3:

$$\xi[P^{(2)}](a_i, t_j, p_{1k}, s_{1q}, s_{2r'}) = \xi[P^{(2)}](a_i, t_j, p_{1k}, s_{1q'}, s_{2r'})$$

for all $i, j, k, q, r, q', r', q \neq q', r \neq r'$

This says that the expected Time-2 Performance for persons with aptitude a_i , total service t_j , Time-1 Performance p_{1k} , Time-1 Satisfaction s_{1q} , and Time-2 Satisfaction s_{2r} is equal to the expected Time-2 Performance for a person with aptitude a_i , total service t_j , Time-1 Performance s_{1q} , but Time-1 Satisfaction $s_{1q'}$, and Time-2 Satisfaction $s_{2q'}$.

Imposing the restrictions implied by the hypothesis on the assumed model results in a restricted model that has no vectors involving either $S^{(1)}$ or $S^{(2)}$.

$$P^{(2)} = a_0U + e_1A + e_2T + e_3(A * T) + e_4P^{(1)} + e_5[P^{(1)} * A] + e_6[P^{(1)} * T] + E^{(4)}$$

The F -statistic is

$$F_3 = \frac{(R_1^2 - R_4^2)/(18 - 7)}{(1 - R_1^2)/(N - 18)}$$

If we accept this hypothesis we might infer that there is no causative effect of satisfaction since persons who are the "same" at Time 1, but who have different satisfaction levels at either time one or at time two or both, have the same Time-2 Performance. However, if we reject Hypothesis 3, it might be of interest to investigate interactions that might exist in a manner similar to Hypothesis 2.

Hypothesis 4:

$$\xi[P^{(2)}](a_i, t_j, p_{1k}, s_{1q}, s_{2r}) - \xi[P^{(2)}](a_i, t_j, p_{1k}, s_{1q'}, s_{2r'}) = k_{qq'rr'}$$

for all $i, j, k, q, r, q', r', q \neq q', r \neq r'$

where $k_{qq'rr'}$ is an unknown difference associated with the satisfaction levels q, q', r, r' .

Imposing these restrictions on Model 1 gives the restricted model

$$P^{(2)} = f_0 U + f_1 A + f_2 T + f_3 (A * T) + f_4 P^{(1)} + f_5 [P^{(1)} * A] + f_6 [P^{(1)} * T] \\ + f_7 S^{(1)} + f_8 [S^{(1)} * S^{(1)}] + f_9 S^{(2)} + f_{10} [S^{(2)} * S^{(2)}] + f_{11} [S^{(2)} * S^{(1)}] + E^{(5)}$$

The F -statistic to test the hypothesis is

$$F_4 = \frac{(R_1^2 - R_5^2)/(18 - 12)}{(1 - R_1^2)/(N - 18)}$$

III. EFFECTS OF JOB PERFORMANCE ON JOB SATISFACTION

Effect of Time-2 Performance on Time-2 Satisfaction

Now consider the question of whether differences in Time-2 Performance result in differences in Time-2 Satisfaction—while controlling for other variables that might be involved. Consider an assumed model

$$S^{(2)} = b_0 U + b_1 A + b_2 T + b_3 (A * T) + b_4 S^{(1)} + b_5 [S^{(1)} * A] + b_6 [S^{(1)} * T] \\ + b_7 P^{(1)} + b_8 [P^{(1)} * P^{(1)}] + b_9 [P^{(1)} * A] + b_{10} [P^{(1)} * T] + b_{11} [P^{(1)} * S^{(1)}] \\ + b_{12} P^{(2)} + b_{13} [P^{(2)} * P^{(2)}] + b_{14} [P^{(2)} * A] + b_{15} [P^{(2)} * T] + b_{16} [P^{(2)} * S^{(1)}] \\ + b_{17} [P^{(2)} * P^{(1)}] + E^{(6)}$$

We can consider four hypotheses about the effects of performance on Time-2 Satisfaction similar to the four hypotheses above. The hypothesis (Hypothesis-5), that Time-2 Performance has no effect on Time-2 Satisfaction controlling for the other variables is tested by using the restricted model

$$S^{(2)} = c_0 U + c_1 A + c_2 T + c_3 (A * T) + c_4 S^{(1)} + c_5 [S^{(1)} * A] + c_6 [S^{(1)} * T] + c_7 P^{(1)} \\ + c_8 [P^{(1)} * P^{(1)}] + c_9 [P^{(1)} * A] + c_{10} [P^{(1)} * T] + c_{11} [P^{(1)} * S^{(1)}] + E^{(7)}$$

The F test is

$$F_5 = \frac{(R_6^2 - R_7^2)/(18 - 12)}{(1 - R_6^2)/(N - 18)}$$

If we accept this hypothesis, we might infer that Time-2 Performance has no causative effect on Time-2 Satisfaction.

If Hypothesis-5 is rejected, it might be of interest to determine if there is any interaction as in Hypothesis-2 above.

The hypothesis (Hypothesis-6) of no interaction between Time-2 Performance and other attributes results in the restricted model

$$S^{(2)} = d_0U + d_1A + d_2T + d_3(A * T) + d_4S^{(1)} + d_5[S^{(1)} * A] + d_6[S^{(1)} * T] + d_7P^{(1)} \\ + d_8[P^{(1)} * P^{(1)}] + d_9[P^{(1)} * A] + d_{10}[P^{(1)} * T] + d_{11}[P^{(1)} * S^{(1)}] + d_{12}P^{(2)} \\ + d_{13}[P^{(2)} * P^{(2)}] + E^{(8)}$$

The F -statistic is

$$F_6 = \frac{(R_6^2 - R_8^2)/(18 - 14)}{(1 - R_6^2)/(N - 18)}$$

Effect of Time-1 and Time-2 Performance on Time-2 Satisfaction

Similar to Hypothesis 3 above, we can test the combined effect of (Hypothesis 7) Time-1 and Time-2 Performance on Time-2 Satisfaction.

The restricted model would be

$$S^{(2)} = e_0U + e_1A + e_2T + e_3(A * T) + e_4S^{(1)} + e_5[S^{(1)} * A] + e_6[S^{(1)} * T] + E^{(9)}$$

The F -statistic is

$$F_7 = \frac{(R_6^2 - R_9^2)/(18 - 7)}{(1 - R_6^2)/(N - 18)}$$

However, if we reject Hypothesis 7, it might be of interest to check for interactions as in Hypothesis 4 above. The restricted model for this hypothesis (Hypothesis 8) is

$$S^{(2)} = f_0U + f_1A + f_2T + f_3(A * T) + f_4S^{(1)} + f_5[S^{(1)} * A] + f_6[S^{(1)} * T] + f_7P^{(1)} \\ + f_8[P^{(1)} * P^{(1)}] + f_9P^{(2)} + f_{10}[P^{(2)} * P^{(2)}] + f_{11}[P^{(2)} * P^{(1)}] + E^{(10)}$$

And the F -statistic is

$$F_8 = \frac{(R_6^2 - R_{10}^2)/(18 - 12)}{(1 - R_6^2)/(N - 18)}$$

IV. OTHER TESTS OF INTEREST

Other questions might be investigated such as

1. The simultaneous effects of $P^{(1)}$, $S^{(1)}$, $S^{(2)}$ on $P^{(2)}$
2. The simultaneous effects of $S^{(1)}$, $P^{(1)}$, $P^{(2)}$ on $S^{(2)}$
3. Various interactions among the many attributes

The assumed models and the tests made should be developed only in the context of the particular operational question being investigated.

V. COMPARING EFFECTS OF PERFORMANCE AND SATISFACTION

The most operationally effective approach to maximizing job performance and job satisfaction is probably through the application of principles of contingency reinforcement and feedback. However, there seems to be some interest in "Comparing the effects of performance and satisfaction."

If it is necessary to compare the effects of Time-2 Satisfaction and Time-2 Performance it might be reasonable to compare

$$F_1 \text{ with } F_5$$

or if the degrees of freedom are different compare

$$\text{Probability Associated with } F_1 \text{ with Probability Associated with } F_5$$

for if the Probability associated with F_1 is smaller than the Probability associated with F_5 , we might infer that changes in Job Satisfaction during Time-2 has more effect on Time-2 Job Performance than changes in Time-2 Job Performance has on Time-2 Job Interest.

Similarly to compare the total effects of Satisfaction on Time-2 Performance with the total effects of Performance on Job Satisfaction we can compare

$$F_3 \text{ with } F_7$$

or

$$\text{Probability Associated with } F_3 \text{ with Probability Associated with } F_7$$

APPENDIX B: CONSOLIDATED BIBLIOGRAPHY OF JOB SATISFACTION— PERFORMANCE RESEARCH, 1956–1974 (EXCLUDING REFERENCES)²

Preface

The purpose of this appendix is to provide a comprehensive listing of studies on the relationship between performance and job satisfaction. Since the first suggestion that job performance and satisfaction were related (Kornhauser and Sharp, 1932), there has been accelerated interest in the interface between these two areas of occupational research. This bibliography and synopsis are therefore intended to review studies linking performance and satisfaction and may be used as a specialized supplement to more general job satisfaction reviews (Tuttle and Hazel, 1974).

The criteria for selection of the studies contained in this appendix were the study's inclusion of at least one job performance, efficiency, or productivity measure, and at least one job attitude or satisfaction measure. Studies concerned with reward or success expectancies were not included unless "expectancies" were theoretically or operationally tied to other job attitudes. Similarly, studies concerned with motivation and career intent were not included unless these job attitudes were related specifically to job performance measures.

The strategy employed to develop this bibliography involved both computerized abstract searches as well as more traditional procedures. The American Psychological Association (APA) Psychological Abstracts Search and Retrieval Service (PASAR)³ provided a substantial number of reports. Two supplemental computerized Defense Documentation Center (DDC) searches⁴ identified another group of studies. Various job satisfaction/work motivation texts, articles, and journals with literature reviews or extensive bibliographies were also examined. In brief, it was felt that the amount of effort expended offered reasonable assurance that a large percentage of the relevant studies on this topic were identified.

Synopsis

The preceding effort resulted in the identification of approximately 140 studies, reports or texts covering about 20 years (1956 through 1974). This number includes 22 of the 40 references listed in the reference section which are not repeated in this appendix. Of the total number, almost 95 percent are from civilian sources. This disproportion is the result of traditional military concern with job satisfaction as it relates to motivation and career intent, rather than as it relates to performance per se (Tuttle and Hazel, 1974). Recently, however, there has been expanded effort to relate objective performance appraisal and job satisfaction in the military services (Cohen and Turney, 1974; Pritchard, Von Bergen, and DeLeo, 1974). Research on performance and satisfaction by the Navy and Air Force was similarly low between 1955 and 1970, but recent publications indicate renewed interest by these services as well (Federman, Lautman, and Siegel, 1973; McDaniel, 1972; Stoloff, 1971).

Figure B-1 illustrates the increasing interest in the study of the relationship between performance and satisfaction during the two decades. Until 1964, less than four studies per year were identified on the topic. In the mid-1960's, an increase in published studies began, reaching a maximum in the early 1970's. However, no formal reviews of the literature were found since Vroom (1964) reviewed 23 early reports. It is noteworthy that this review roughly coincides with the beginning of the sharp upward trend in 1965. However, many areas of job satisfaction research increased rapidly after the mid-1960's.

The studies reviewed may be categorized in four overlapping groups; those that sought to (1) test implications of related instrumentality, expectancy, or equity theories, (2) manipulate reward to observe its effects on laboratory task performance and task enjoyment, (3) identify variables which modify the performance-satisfaction relationship, and (4) estimate source and direction of causal influence using panel correlation techniques. These general interests are discussed briefly below.

² For consistency, all citations in this Appendix are listed in the preceding reference section.

³ APA-PASAR Search SR-431, April 1972, entitled "Job Satisfaction." Fourteen index terms and six keywords were used, resulting in 556 "hits."

⁴ Defense Documentation Center, Alexandria, VA. Report Bibliographies for Search No. 082500 (Job-Work Satisfaction in the Military Services) and DDC-TAS-68-37 (Retention, Work Motivation, and Retirement of Military Personnel.)

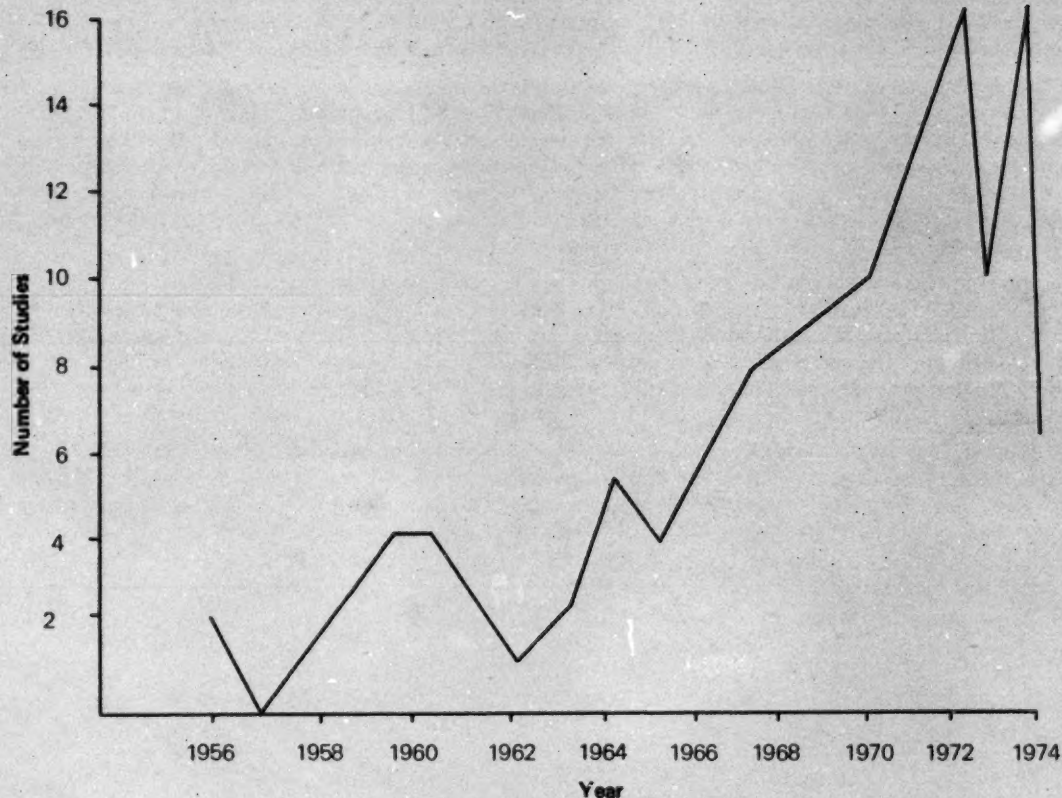


Figure B-1. Number of performance-satisfaction studies by year

Because the performance-satisfaction topic has traditionally been classified within the broader area of job satisfaction research, there are no theories exclusively identified as "performance-satisfaction" theories, and few of the studies listed may be attributed to the implications of any theory. The research is marked, rather, by diverse subject samples, definitions, and moderating variables. The classic works of Herzberg (Herzberg, 1966; Herzberg, Mausner, and Snyderman, 1959) and Porter and Lawler (1968) have provided the basis for studies seeking to identify causal relationships between performance and satisfaction. The earlier view was that job performance is the result of expectancy attitudes fostered in a satisfying work environment (Herzberg, 1966), and the later view attributed to Porter and Lawler (1968), was that job performance creates positive "expectancies" for reward. Between these viewpoints have been theories suggesting that performance-satisfaction relationships are a function of balance (Korman, 1970) and equity (Locke, 1970).

None of the preceeding theoretical statements has significantly guided the performance-satisfaction research. This observation, in fact, has led some recent investigators to suggest it is of questionable value to study performance and satisfaction without considering reward as a third factor (Pritchard, 1969). Thus a second approach to performance-satisfaction relationships has been to observe causal relationships between reward, performance, and task liking in the laboratory. Several of these studies may also be classified as "equity" experiments (Pritchard, Dunnette, and Jorgenson, 1972).

The vast majority of the studies listed in the bibliography are single time (i.e., static) studies involving single subject samples and the measurement of simple correlations between one measure of satisfaction and one of performance, under different moderating conditions. These concomitant variables have included reward, motivation, organizational level, occupation, work climate, valence of work role, ability-task

requirements match, and many others. Many were concerned with performance as a secondary factor. For this reason the studies are difficult to compare, although it is clear from the overall situation that the correlation between performance and satisfaction may vary depending on a very large number of factors.

The tendency of many researchers to infer causality has led a good number of recent investigators in this area to apply panel correlation techniques (Yee and Gage, 1968) to infer causality in field work situations. The performance-satisfaction topic appears to have attracted more cross-lagged correlation designs than any other topic in psychology, as four of the 24 studies identified as partially concerned with performance and satisfaction in 1973 and 1974 were cross-lagged correlation studies (Federman, Lautman and Siegel, 1973; Greene, 1973; Lawler and Suttle, 1973; Wanous, 1974).

A chronological analysis of the specific topics covered by reports listed here revealed that interests and terminology have changed considerably without apparent consensus. In the late 1930's through 1950's, performance was termed "productivity, success, proficiency," or "satisfactoriness," and it was related to interest, reenlistment intent and general measures of satisfaction, none of which were clearly comparable. The early period of loosely related performance-satisfaction research ended with *The Motivation to Work* (Herzberg, Mausner, and Snyderman, 1959), which provided the first theoretical statement necessary to sustain interest on the question.

In the early 1960's enough research had been accomplished in the area to generate interest in situational constraints, or moderating conditions, which could be observed to affect the performance-satisfaction relationship. In the early 1960's, these included *both* subject and job characteristics, such as ego involvement and job difficulty.

The increased number of performance-satisfaction studies since 1965 included interest in laboratory task performance, work motivation-satisfaction theory, cross-lagged analysis, and a wider variety of moderating variables. Personality variables related to the performance-satisfaction relationship included self-esteem, need for achievement, and role perception; job variables included complexity, reward contingencies, and salary, among many others.

Considerable controversy was generated, beginning in the late 1960's, as a result of these varied perspectives on the topic. No consensus was apparent during the last part of the period covered by this bibliography, however. Nearly half of the studies in 1970 through 1974 were theoretical and integrative in nature, although there has been no recent formal review of the literature. Position statements have covered all possible approaches, including considering satisfaction and performance as moderators of relationships involving other variables. In this regard it is interesting to note that in 1955 Brayfield and Crockett concluded that there was no observable relationship between performance and satisfaction, but satisfaction was best considered a moderator of ability-performance relationships.

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